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ABSTRACT

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LEXICAL INFORMATION IN MEMORY FOR TEXT

Barbara Hayes-Roth

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March 1977

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Abstract

Cued-recall and two-alternative, forced-choice recognition measures were used to evaluate subjects' retention of the specific wordings of studied texts. Results obtained after ten-minute and twenty-four hour retention intervals suggest that the studied wordings of texts are functional components of their memory representations. Theories that assume automatic lexical decomposition during text comprehension cannot account for these results. However, the results are consistent with either associative network theories in which word-senses are the basic units of representation or theories that assume both lexical decomposition and the retention of specific lexical information.

Many theories assume that linguistic materials are decomposed into semantic constituents during comprehension and that only these semantic constituents, rather than specific wordings, persist in memory (Anderson, 1971; Anisfeld, 1969, Anisfeld & Knapp, 1968; Bobrow, 1970; Bransford & McCarrell, 1974; Brewer, 1975; Clark, 1974; Fillenbaum, 1966, 1969, 1971; Grossman & Eagle, 1968; Jackendoff, 1975; Miller, 1972, 1974, 1975; Osgood, 1968; Peterson & MacIntyre, 1974; Sachs, 1974; Schank, 1972a, 1972b, 1975; Wellborn & English, 1937; Wilks, 1972). An alternative view of memory is that words, or word-senses, are the basic units of representation. Several of the associative network theories (e.g., Anderson & Bower, 1973; Collins & Loftus, 1975; Kintsch, 1972; Rumelhart, Lindsay & Norman, 1972) reflect this view of memory.

In a recent paper, Hayes-Roth and Hayes-Roth (1977) reported three experiments on sentence memory, whose results supported the associative network theory over lexical decomposition theories. Experiment 1 showed that subjects recognized the original wordings of previously studied sentences more confidently than synonymous wordings. If subjects had stored only semantic constituents of the studied sentences they should have recognized the original wordings and synonymous wordings with equal confidence. Experiment 2 showed that subjects verified previously studied propositions faster if they preserved the original wordings than if they incorporated synonymous wordings. If subjects had stored only semantic constituents, they should

have verified the original wordings and synonymous wordings equally fast. Experiment 3 showed that the presence of common words in two learned sentences caused interference (longer verification times), while the presence of synonymous words did not. If subjects had stored only semantic constituents, common words and synonymous words should have produced comparable interference effects. These results suggest that the specific wordings of studied materials are retained as functional components of memory representations. Of course, the results do not rule out theories that assume both lexical decomposition and the retention of specific wordings. However, Hayes-Roth and Hayes-Roth argued that all of the results reported in this area can be accounted for without assuming lexical decomposition. Since many of the results are explainable only if one assumes the retention of specific wordings, an associative network theory in which word-senses are the basic units of representation appears to be the most parsimonious theoretical alternative.

The present experiment further investigated predictions of the associative network theory. Subjects read a series of paragraphs, ostensibly in preparation for a comprehension test. After they had finished reading, and following a variable retention interval, subjects were given two tests. The first was a cued-recall test. The paragraphs were presented intact, except that one word in each sentence was replaced by a blank. The subject's task was to fill the blank with the specific word that had appeared in the originally studied text. The second test was

a two-alternative, forced-choice recognition test. The paragraphs were presented again, except that the blank line present in the cued-recall test was replaced by a pair of words, the originally presented word and a synonym. The subject's task was to circle the originally presented word.

The predictions of the associative network theory are straightforward. The theory assumes that the specific words used in the studied paragraphs are the basic units of its memory representation. There should also be a spreading of excitation to semantically related representations in memory. This means, among other things, that there may be memory traces representing synonymous wordings of studied paragraphs. However, those traces should be weaker than traces representing the originally studied wordings. Thus, although subjects may recall or recognize synonyms (associates) of the originally studied wordings, they should recall and recognize the originally studied (exact) wordings more often and with higher confidence.

The present experiment elaborated the Hayes-Roth and Hayes-Roth (1977) experiments in several ways. First, the experiment investigated memory representations of nouns, adjectives, and verbs, rather than just verbs. Second, the experiment concerned the representation of information acquired from text in a natural reading task, rather than from unrelated sentences. Anderson and Bower (1973) have suggested that subjects retain lexical information from unrelated sentences, but not from text. On the other hand, Dooling, Christiaansen, and Keenan (1975), while

arguing that lexical information is ultimately lost, have suggested that it is retained temporarily even from text. Third, the dependent variables in this experiment were cued recall and two-alternative, forced-choice recognition. Brewer (1975) has observed that subjects produce at least as many synonymous intrusions as correct responses in a cued-recall test of sentence memory. This result would be problematic for the associative network theory, except that it appears to have been produced, at least in part, by Brewer's having used only those sentences "that had shown the strongest tendency to give recall shifts in earlier experiments" (p. 460). The cued- recall task in the present experiment was intended to determine whether Brewer's observation would obtain in a conventionally counterbalanced design. However, cued recall is a relatively insensitive measure; it may be that specific lexical information is present in memory, but not in a form strong enough to produce differences in recall. The recognition task should be more sensitive and was included for that reason. Finally, two retention intervals, ten minutes and twenty-four hours, were included in order to assess the relative prominence of lexical information over time.

Method

Design and Procedure. Six paragraphs were typed, one to a page, in booklets. Subjects were instructed to work through the booklets carefully at their own rates, studying each paragraph in preparation for a comprehension test. After reading the six paragraphs, half the subjects left and returned to continue the

experiment the next day. Next, subjects worked through a set of thirty-five addition problems. Then they were given the cued recall test. Paragraphs again were typed one to a page. However, in each sentence, a particular word was omitted and replaced by a blank. Subjects were told to try to fill in the exact words that had been present in the paragraphs they had studied. They were encouraged to guess if they could not recall the correct words, but were required to indicate their confidence in the accuracy of their responses on a five-point scale. Then subjects were given the recognition test. Here, the word that had been replaced by a blank in the cued recall test was replaced by a pair of words, the correct word and its synonym, in random order and surrounded by parentheses. Subjects circled the words they thought had appeared in the original paragraphs and again indicated their confidence. Finally, subjects were given an identical meaning test. Each sentence in each paragraph was presented in two forms: one included the test word that had actually occurred in the original paragraph and one included its synonym. Subjects indicated whether each pair of sentences had identical meanings. Only those sentences for which subjects had affirmed identical meanings were included in the analysis.

Materials. Subjects worked with sets of six eight-sentence paragraphs. Each sentence in each paragraph contained one word whose synonym occurred in a sentence in some other paragraph. These paired synonyms were the words on which subjects were tested subsequently. Of the forty-eight synonymous words in a

set of paragraphs, eighteen were nouns, eighteen were verbs, and eighteen were adjectives. Two unique sets of six paragraphs were constructed. Each set was used for half of the subjects in each of two retention-interval conditions. In addition, the particular paragraphs in which members of a synonymous pair occurred were exchanged for half the subjects who worked with each set of paragraphs in each retention interval condition.

Subjects. Subjects were eighty students at Fairleigh-Dickenson University. They were paid for their participation.

Results and Discussion

Three performance measures were computed and evaluated for both cued-recall and recognition performance. The first measure was the percent of responses made in each of the alternative response categories (correct words and synonyms for recognition performance; correct words, synonyms, and incorrect words for cued-recall performance). The second measure was the mean confidence rating with which responses in each of the alternative response categories were made. The third was the percent of the total possible response confidence (number of responses x five) with which responses were made in each of the alternative reponse categories. The third measure is the most informative because it incorporates both kinds of information in the other two measures. Although the first two measures and the third measure are not independent, it is interesting to look at all three in order to assess the individual as well as combined effects of the first two.

Figure 1 shows cued-recall performance following the ten-minute retention interval. Cued-recall responses were categorized as correct words if they were the words present in the paragraphs subjects had read. They were categorized as synonyms if they were words designated synonyms within the experiment or if they were close in meaning to the presented words. Responses were categorized as incorrect words only if their meanings were inappropriate, given what subjects had read.

Figure 1 shows the percent of recall responses, the mean confidence of recall, and the percent of recall confidence across the three response categories. The data are plotted separately for nouns, verbs, and adjectives. All three measures indicate better recall of correct words than synonyms and better recall of synonyms than incorrect words.

Figure 2 shows two-alternative, forced-choice recognition performance following a ten-minute retention interval. Figure 2 shows the three response measures for the two response categories, with the data plotted separately for nouns, verbs, and adjectives. All three measures indicate better recognition of correct words than synonyms.

Figure 3 shows cued-recall performance following a twenty-four-hour retention interval. Figure 3 shows the three response measures for the three response categories, with the data plotted separately for nouns, verbs, and adjectives. The three measures indicate better recall of correct nouns than synonymous nouns, but they do not discriminate recall of correct verbs or

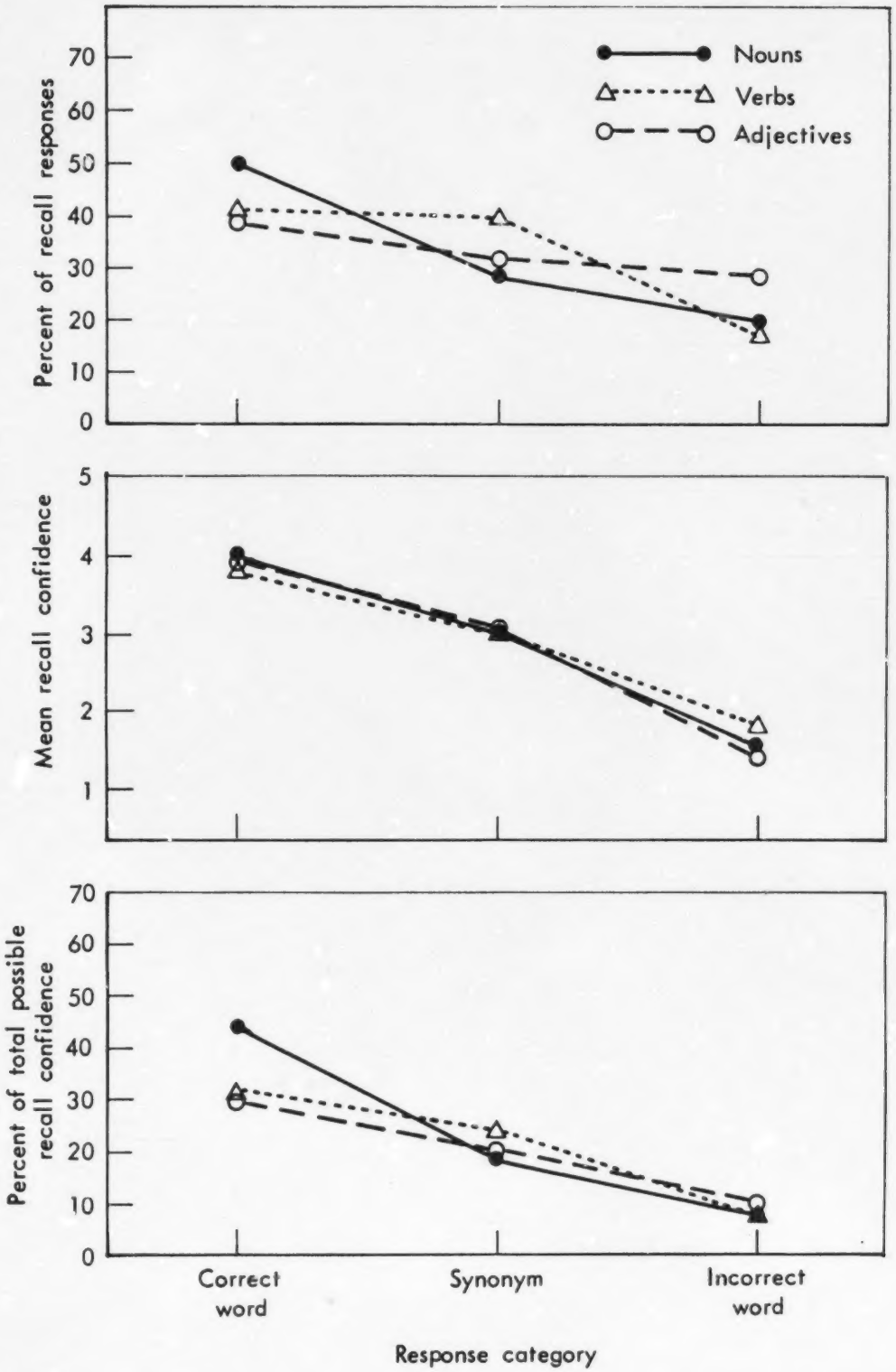

Figure 1. Cued-recall performance following a ten-minute retention interval.

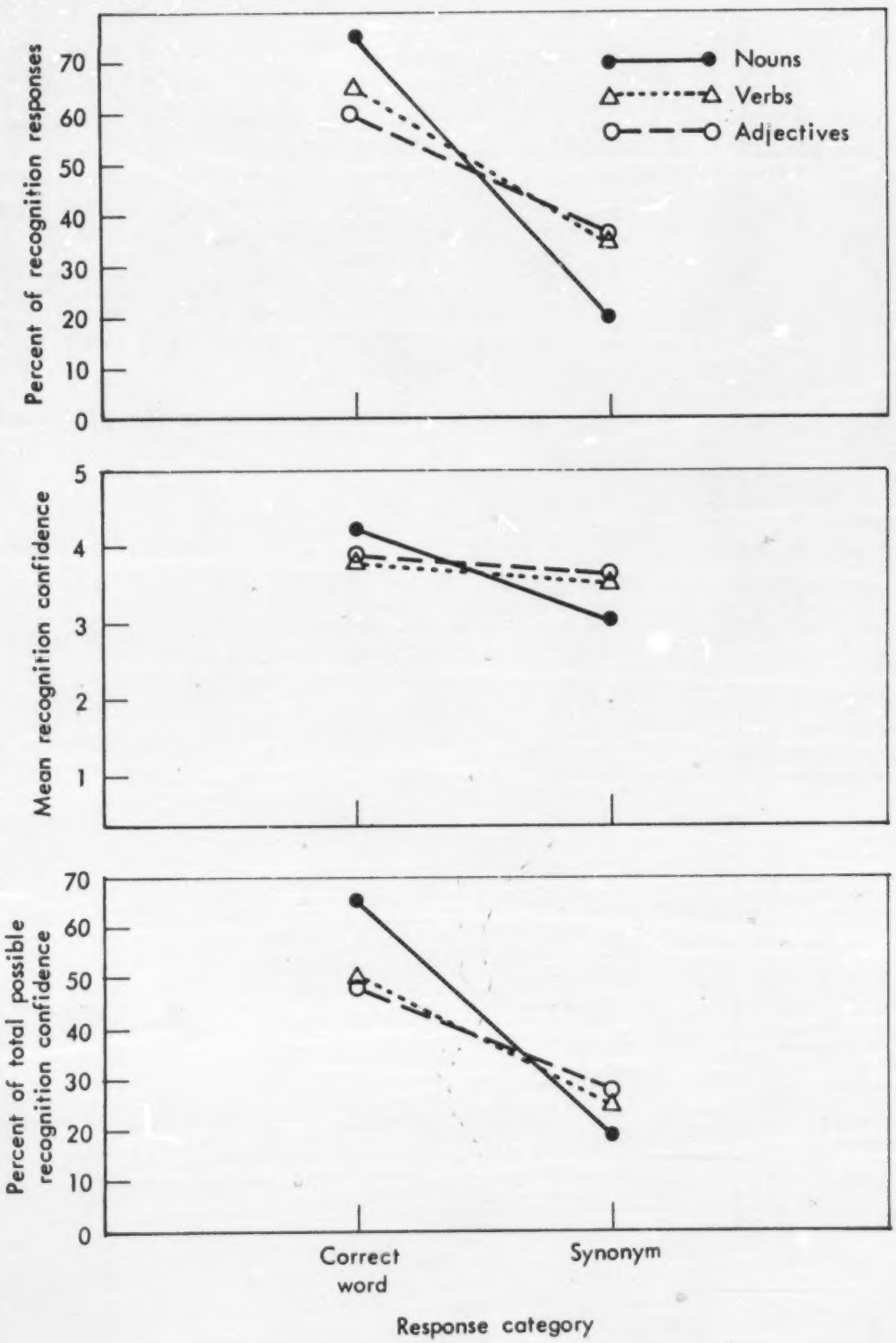

Figure 2. Two-alternative, forced choice recognition performance following a ten-minute retention interval.

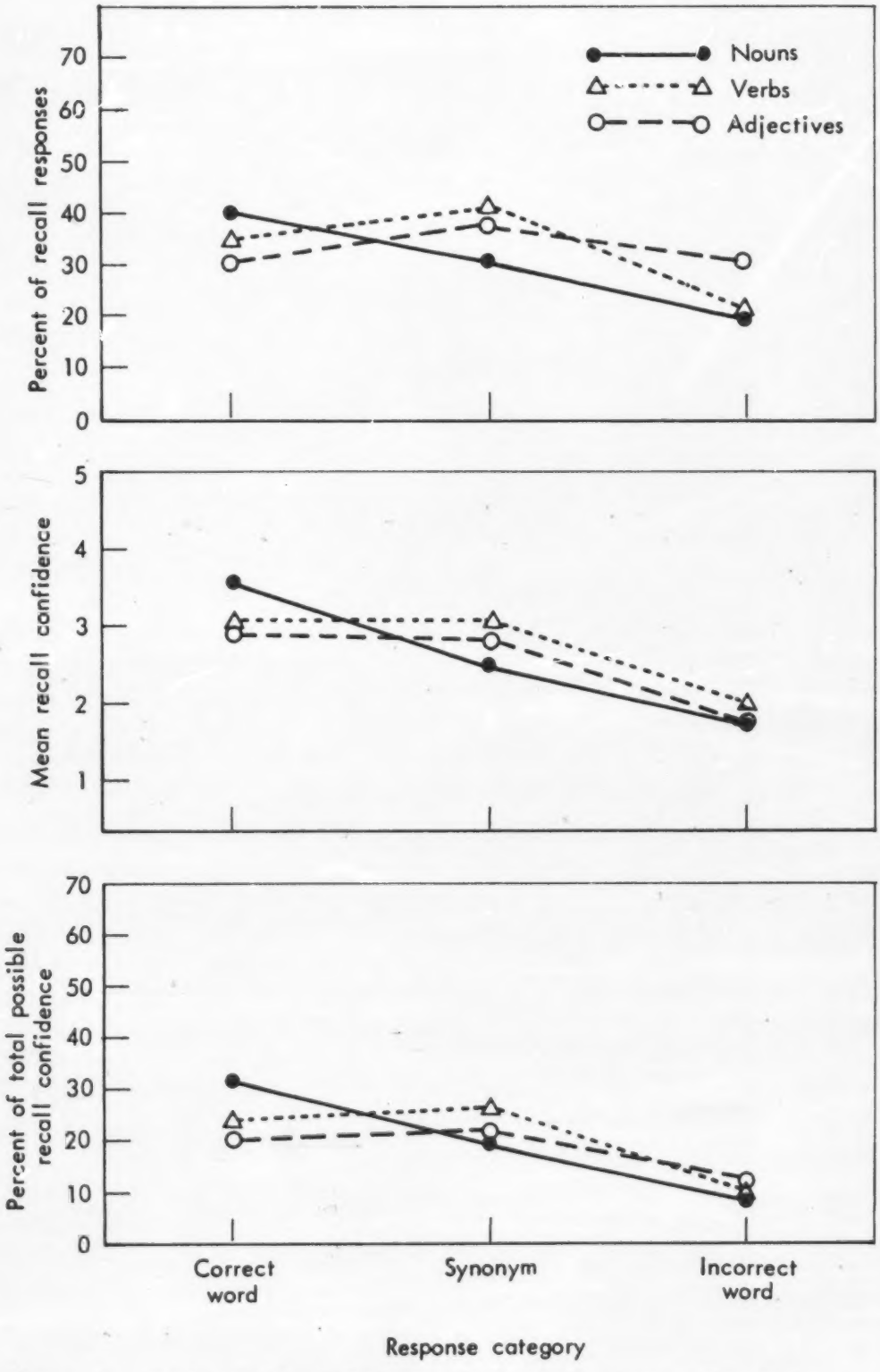

Figure 3. Cued-recall performance following a twenty-four-hour retention interval.

adjectives from recall of synonymous verbs or adjectives. All three measures indicate better recall of correct or synonymous words than incorrect words.

Figure 4 shows two-alternative, forced-choice recognition following a twenty-four-hour retention interval. Figure 4 shows the three response measures for the two recognition response categories, with the data plotted separately for nouns, verbs, and adjectives. All three measures indicate better recognition of correct words than synonyms.

Table 1 summarizes the cued-recall and recognition results for correct words versus synonyms. Each entry in the table signifies whether performance was better for correct words (c), synonyms (s), or neither (-). The data were submitted to an analysis of variance and planned comparisons were performed to evaluate the reliability of the observed differences. A "*" following an entry signifies that the performance differential was statistically reliable at the .05 level or better.

Table 1 provides strong evidence of the retention of specific lexical information in memory representations of text, as assumed by the associative network theory. All of the comparisons at the ten-minute retention interval indicated superior performance on correct words compared to synonyms. At the twenty-four-hour retention interval, the comparisons involving recall of nouns and all of the recognition comparisons indicated superior performance on correct words. Only those comparisons involving recall of verbs and adjectives at the

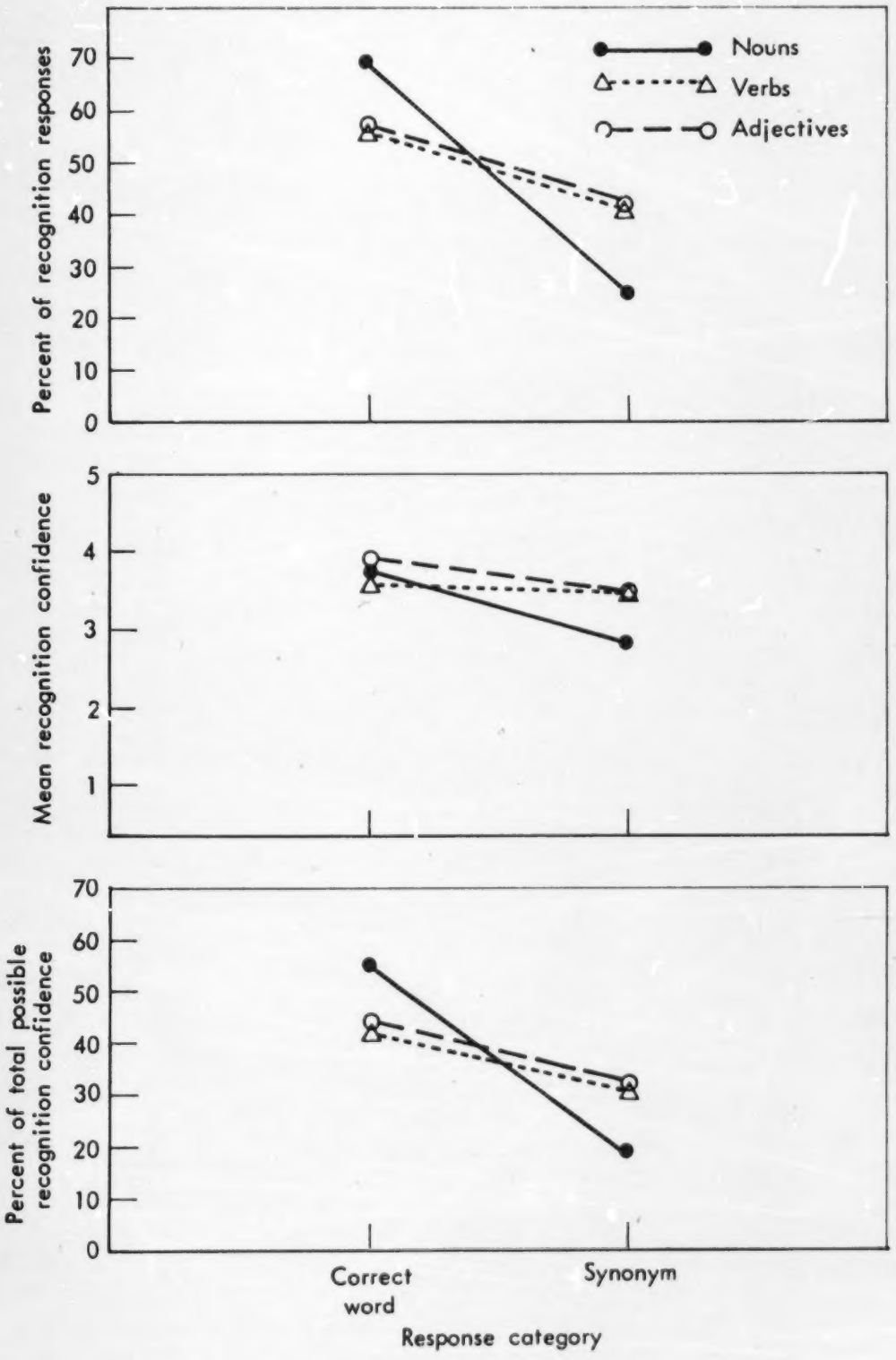

Figure 4. Two-alternative, forced-choice recognition performance following a twenty-four-hour retention interval.

Table 1

Summary of Differences in Cued Recall and Recognition of Correct Words Versus Synonyms

Part of Speech	Retention Interval: Ten Minutes			Retention Interval: Twenty-four Hours		
	Percent Responses	Mean Confidence	Percent Confidence	Percent Responses	Mean Confidence	Percent Confidence
Cued Recall						
Nouns	c*	c*	c*	c*	c*	c*
Verbs	c	c*	c*	s	-	s
Adjectives	c	c*	c*	s	c	s
Recognition						
Nouns	c*	c*	c*	c*	c*	c*
Verbs	c*	c	c*	c*	c	c*
Adjectives	c*	c	c*	c*	c*	c*

twenty-four-hour retention interval failed to indicate superior performance on correct words and none of those comparisons reflected statistically reliable peformance differentials.

This last result is neither surprising nor particularly damaging to the associative network theory, since cued-recall is a fairly insensitive indicator of the contents of memory. Further, the scoring of any recalled word that was semantically related to the originally studied word as a synonym biased the analysis against finding better performance on correct words than synonyms. The associative network theory assumes that originally studied wordings have the strongest memory representations and, therefore, the highest probabilities of recall. However, every synonymous wording also has a memory representation and, therefore, some probability of recall. The theory predicts that an originally studied wording should be recalled more often than any particular synonymous alternative. It does not predict that an originally studied wording should be recalled more often than the entire set of semantically similar alternatives. Thus, from the point of view of the associative network theory, the synonym scoring method unfairly inflated the percent recall of synonyms, compared to the percent recall of correct words.

Table 1 shows that exact wordings of studied texts are retained at both ten-minute and twenty-four-hour retention intervals. However, significant interaction effects (at the .05 level) suggest that the discriminability of correct and synonymous wordings decrease as the retention interval increases.

That is, the superiority of performance for correct words is greater at the shorter lag. One of the assumptions of the associative network theory, as outlined by Hayes-Roth and Hayes-Roth (1977), is that the strength of a memory representation is a decreasing function of the time since its last activation. In the present experiment, as the retention interval is increased, the differential strengths of representations of the originally studied and synonymous wordings are presumed to regress toward some common asymptotic strength. Thus, the theory predicts the observed decrease in the superiority of performance for correct words over synonyms as the retention interval increases.

Table 2 summarizes the cued-recall results for synonyms versus incorrect words. Every entry in the table indicates that recall was better for synonyms than for incorrect words, with only three of the recall advantages failing to reach statistical significance. These results illustrate that sometimes subjects can produce the meanings of studied texts even when they cannot produce the original wordings. This finding is consistent with the associative network theory's assumption that retrievable traces of synonymous (and other semantically related) wordings of the studied texts are established in memory as a consequence of spreading activation during study.

The results discussed above are consistent with the predictions of the associative network theory. They are inconsistent with theories that assume automatic lexical decomposition and the loss of specific lexical information.

Table 2

Summary of Differences in Cued Recall of Synonyms Versus Incorrect Words

Part of Speech	Retention Interval: Ten Minutes			Retention Interval: Twenty-four Hours		
	Percent Responses	Mean Confidence	Percent Confidence	Percent Responses	Mean Confidence	Percent Confidence
Noun	s	s*	s*	s*	s*	s*
Verb	s*	s*	s*	s*	s*	s*
Adjective	s	s*	s*	s	s*	s*

However, they are also consistent with more elaborate theories postulating both lexical decomposition plus retention of specific lexical information. An example of this kind of theory, reflecting the Craig and Lockhart (1972) levels of processing framework, has been proposed by Dooling, Christiaansen, and Keenan (1975): "We assume that comprehension of a prose passage involves the activation of numerous memory codes that simultaneously exist at various levels of abstraction. Lower codes are lost early in the retention interval, higher codes persist." In such a framework, presumably, the meanings of studied texts have persistent high-level memory codes while the lexical forms of studied texts have relatively short-lived, low-level memory codes. Although the two classes of theories cannot be discriminated by currently available data, they do propose quite different memory mechanisms. The theory proposed by Dooling, Christiaansen, and Keenan (1975) postulates the existence of multiple, qualitatively different memory codes, which also differ in durability. The associative network theory, on the other hand, assumes a single kind of memory code associated with a variable strength parameter. Thus, the associative network theory appears to make fewer assumptions than the combined theory. Furthermore, it has also been argued elsewhere (Hayes-Roth & Hayes-Roth, 1977) that the associative network theory entails more efficient mechanisms for representation, input, access, interference, and inferential reasoning than theories based on multiple codes. Nonetheless, it

remains to be determined which of the two theories provides the better description of human memory.

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